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Seaport Productivity in a Developing Economy: An Empirical Evidence from Nigerian Seaports

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ABSTRACT

This study focuses on assessing the efficiency of Nigerian ports from 2008 to 2017 by applying Data Envelopment Analysis. The data were sourced from Nigeria Port Authority Abstract from 2008 to 2017, for three seaports (Apapa, Onne and Rivers port). Cargo throughput, Labour/Personnel, Ship traffic, Vessel turnaround time, and Berth occupancy are the variables used to measure the operational performance of the ports and Data Envelopment Analysis – Charnes Cooper Rhodes/Constant return to scale (CCR/CRS model) model was used to determine their technical efficiency over time. The results reveal that Onne port and Apapa port's technical efficiency is 1 (One) and Rivers port is 0 (Zero); meaning that Rivers port is not performed efficiently compared to Onne port and Apapa port over the ten-year period under study. The Policy implications for Nigerian ports are that Rivers port should be privatized completely to improve its efficiency and Onne port should be used to benchmark the ports in Nigeria.

Keywords: Efficiency, Data Envelopment Analysis, Performance, Assessment, and Seaports

1. INTRODUCTION

A port is an area on a coast or shore containing at least one harbor where ships can dock and move cargo or people to or from land. Port areas are chosen to improve access to land and navigable water, and for the need for shelter from wind and waves and business demands. Ports are the major commercial and industrial centre for the social and economic development of the nation.

The ports have consistently been disposed to changes in social and economic patterns bringing about development. These developments have created a highly uncertain and complex environment for ports and fundamentally changed the port concept. The seaport is a multidimensional framework involving economic functions, geographical space, infrastructural systems, and trade. The role played by seaports in the maritime logistics chain necessitates that the administration apparatus utilize Performance Evaluation Models as proficient as those used to decide sea routes (Dutra et al. 2015).

It has been noted that West African ports are highly congested and inefficient, compared to ports in Europe and Asia (AFDB, 2010). Highly congested ports have direct impacts on the costs of doing business. According to Leigland and Palsson (2007), "Nigerian Ports demonstrate very low levels of efficiency which results in high turnaround time of the ship and increased dwell time of containers at the ports". Instead of the forty-eight-hour international standard needed to load and unload a ship, it takes weeks in Nigerian ports. Apapa port was ranked 4th among Tema, Abidjan, Dakar, Lome, and Cotonou, which are the West African major seaports (van Dyck, G.K. 2015). For Nigerian ports to be the hub of West Africa, it needs to run its ports efficiently. An efficient port will always be user friendly and will boost the economy through revenue generation and employment opportunities (Stephens & Idowu, 2020).

Determining the efficiency levels at which the ports are being operated will inform the right advice to the policymakers on "how and what to do", to make the ports perform efficiently and achieve the aim of becoming the West Africa hub.

2. LITERATURE REVIEW

Performance measurement plays a significant role in the improvement of seaports or an organization. Therefore, all ports utilize various methods to examine their level of performance. Port performance can be measured in terms of the number of cargo throughput of containers moved through the seaport with the assumption that seaports are throughput maximizers. Performance can be characterized or defined as the ability to produce positive outcomes or results, which is also depending the desires or expectations (Ducruet, C. 2009).

Efficiency is defined as the measure of efficiency that produces the minimum waste of time, effort, and skill. It is the ability of seaports or organization to utilize its resources to produce outputs of a given quality, or the optimal use of resources to produce outputs of a given quality.

Measurement of efficiency is directly related to the measurement of productivity. A Seaport is regarded as 'efficient' or 'highly productive' if it can produce a maximum output for given inputs or uses minimal inputs for the production of a given level of output (Notteboom et al., 2000).

Data Envelopment Analysis (DEA) is one of the major ways of measuring efficiency. The theoretical development of DEA began with Edward Rhodes' Thesis published in 1978, for obtaining a Doctoral Degree under the supervision of W. W. Cooper. A mathematical programming model applied to observational data provides a new way of obtaining empirical estimates of relations, such as production functions or efficient production possibility surfaces that are cornerstones of modern economics (Charnes, Cooper, and Rhodes, 1978). DEA is a nonparametric linear programming methodology that evaluates the relative technical efficiency of decision-making units (DMUs), represented in this study as ports. This methodology analyzes the optimal combination between inputs and output, based on the observed performance of each DMU. These combinations form the efficiency boundary for determining the relative efficiency levels.

In the same vein, Performance Frontier is the maximum performance that can be attained or achieved by a production unit given a set of operating choices. It is very similar to a production or manufacturing performance index or a manufacturing performance score (Voss et al., 1995; Vastag and Narasimhan, 1998). The Performance Frontier is classified into operating and asset frontiers. Asset frontier is less important than the operating frontier in accomplishing a sustainable competitive edge or advantage, because resources that are soft, valuable, rare, and specific to a given organization, and they are not easy to duplicate. It therefore follows that survey-based methods in themselves are not well suited to explore and determine the infrastructure-based sources of competitive edge or advantage of a port.

vanDyck (2015) studied the efficiency of ports in West Africa using Data Envelopment Analysis and found that the Port of Tema was the most efficient in West African, with the ports of Abidjan and Lomé closely following and the Port of Cotonou being the least efficient. Anyadiegwu (2014) assessed the efficiency of Nigerian ports using Data Envelopment Analysis and found that there has been a continuous improvement in the overall efficiency of the ports since the ports were privatized in 2006.

This study uses DEA for a comparative analysis of Apapa port (West), Onne port (East) and Rivers port (Central), with the input variables as ship traffic, ship turnaround time, berth occupancy and labour, and cargo throughput as the output variable. Time series data from 2008-2017 was deployed for the analysis.

3. RESEARCH METHODOLOGY

The data used were secondary data sourced from Nigerian Ports Authority Abstracts of statistics from 2008 to 2017. The study focuses on three ports from three major regions in Nigeria. Apapa port was selected from the Western region, Onne port was selected from the Eastern region, and Rivers port was from the Central region. The selected seaports were considered because of

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their cargo throughput. Data Envelopement Analysis Program (DEAP) was used for the analysis and Constant Return to Scale (CRS-Model) was used to determine the technical efficiency of the ports. CRS-Model determines the efficiency of the port by making use of ports' input and output variables. In this study, 4 input variables (labor, turnaround time, berth occupancy, ship traffic) and one output (cargo throughput) were used.

3.1 Model Formulation

The basic mathematical formulation of DEA-CRS has the following form: Suppose n decision-making units (DMUs), where every DMUj, j = 1, 2,... ., n produces the same s output in possibly different amounts, yrj(r = 1, 2. . ., s), using the same m inputs, xij(i = 1, 2,. . .m), also in possibly different numbers, u and v are weights that are assigned, respectively, to the outputs and inputs obtained when solving the model. The efficiency of a specific DMUp can be evaluated using model (1) with the CRS assumption.

$\text{Max}\theta_p = \{\sum_{r-1}^{s} u_r y_{rp}\}$

Subject to: $\{\sum_{i-1}^{m} v_i x_{ip}\} = 1$

$$\sum_{r-1}^{s} u_r y_{rj} - \sum_{i-1}^{m} v_i x_{ij} \leq 0; \forall\, j$$

$u_{rb}, v_{ib} \geq 0$where i=1, 2, . . . ,m denotes the number of inputs (x), j = 1, 2, . . . ,p, . . . , n denotes the number of DMUs, and r = 1, 2, . . . , s denotes the number of outputs (y). This search procedure will terminate when some of the efficiencies hit 1.

4. DATA ANALYSIS AND DISCUSSION OF RESULTS

Table 4.1 Summary of Descriptive Statistics for the Sample

Variables	Valid Values	Missing Values	Mini	Maxi	Average	Medium	Std dev	EstStddev
Labour	30	0	202	726	422.7	405	173.185	176.145
Turnaround Time	30	0	2.4	10.5	4.90733	3.98	2.53037	2.57363
Berth Occupancy	30	0	18.4	75.36	50.0517	55.6	16.3595	16.6392
Ship Traffic	30	0	121704	4.55438E7	2.1954E7	2.69493E7	1.648E7	1.67617E7
Cargo Throughput	30	0	3.14494E6	2.79689E7	1.58835E7	2.01042E7	9.0281E6	9.18243E6

Source: Author

Table 4.1 shows the summary of descriptive statistics for the three seaports in Nigeria from each zone (Western, Eastern, and Central Ports), with time-series data of 10 years.

4.2. Comparative Analysis of Seaport Performance and Technical Efficiency Scores using CRS-Model

Table 4.2 below shows the technical efficiency summary (TE) for the seaports and ranks under the period of study, with the decision-making units arranged in line with the level of technical efficiency of the ports and their years.

Table 4.2: Technical Efficiency (TE) of the seaports and their rank under periods of study.

DMUs	Technical Efficiency (TE) Score	Rank
Apapa 2010	1	1
Onne 2010	1	1
Onne 2012	1	1
Onne 2014	1	1

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Onne 2016	1	1
Onne 2011	0.954	6
Onne 2017	0.931	7
Onne 2015	0.883	8
Onne 2013	0.866	9
Apapa 2014	0.572	10
Rivers 2010	0.564	11
Apapa 2015	0.55	12
Apapa 2013	0.471	13
Apapa 2009	0.461	14
Apapa 2016	0.461	14
Apapa 2017	0.457	16
Apapa 2011	0.455	17
Apapa 2008	0.452	18
Apapa 2012	0.405	19
Rivers 2011	0.27	20
Rivers 2014	0.265	21
Rivers 2008	0.235	22
Rivers 2012	0.23	23
Rivers 2013	0.211	24
Rivers 2015	0.177	25
Onne 2009	0.161	26
Rivers 2016	0.154	27
Rivers 2017	0.154	27
Onne 2008	0.129	29
Rivers 2009	0.129	29
Mean	0.52	

Source: Author

Table 4.2 shows the technical efficiency scores of the seaports understudied and ranks. The table reveals that in the year 2010, Apapa port was efficient with TE score =1. Onne port was also efficient in 2010, 2012, and 2014 with a TE score of 1. Whereas, Rivers port has never been efficient from 2008 to 2017. Apapa port was not efficient in 2008, 2009, 2011, 2012,2013, 2014, 2015, 2016, and 2017 because the TE scores in those year were 0.452, 0.461, 0.455, 0.405, 0.471, 0.572, 0.55, 0.461 and0.457 respectively. Onne Port was inefficient in the following years: 2008 with an efficiency score of 0.129, 2009 with an efficiency scoreof 0.161, 2011 with an efficiency scoreof 0.954, 2013 with an efficiency score of 0.866, 2015 with an efficiency score of 0.883 and 2017 with an efficiency score of 0.931. Rivers port was not efficient in all years. In 2008 the efficiency score was 0.235 , 2009 efficiency score was 0.129, 2010 efficiency score was 0.564, 2011 efficiency score was 0.27, 2012 efficiency score was 0.23, 2013 efficiency score was 0.211, 2014 efficiency score was 0.265, 2015 efficiency score was 0.177, 2016 efficiency score was 0.154, and 2017 efficiency score was 0.154.

Figure 4.1 presents the curve of TE of DMUs over the period of the study. It shows the seaport efficiency summary curve and seaports on the frontier are fully represented in the graph.

The technical efficiency summary in Table 4.2 shows that Nigerian ports are for most of the years not running efficiently. The Onne port was found to be the most efficient among the ports compared over the 10 years of study. Onne was efficient for 4 years (2010, 2012, 2014, and 2016). The reason for this is not far-fetched, as there is a shift in shipping towards Onne port. The port is closer to the southerners and easterners, and less congested compared to Apapa. The years it was inefficient could be attributed to a global economic or financial meltdown, especially in 2008 and 2009. Moreover, the efficiency of the port was affected by the Niger Delta militants.

Apapa port was efficient in the year 2010. However, in 2008 and 2009, Apapa port was not efficient as a result of the global financial meltdown. For the rest of the year, Apapa port was inefficiency mainly due to traffic congestion.

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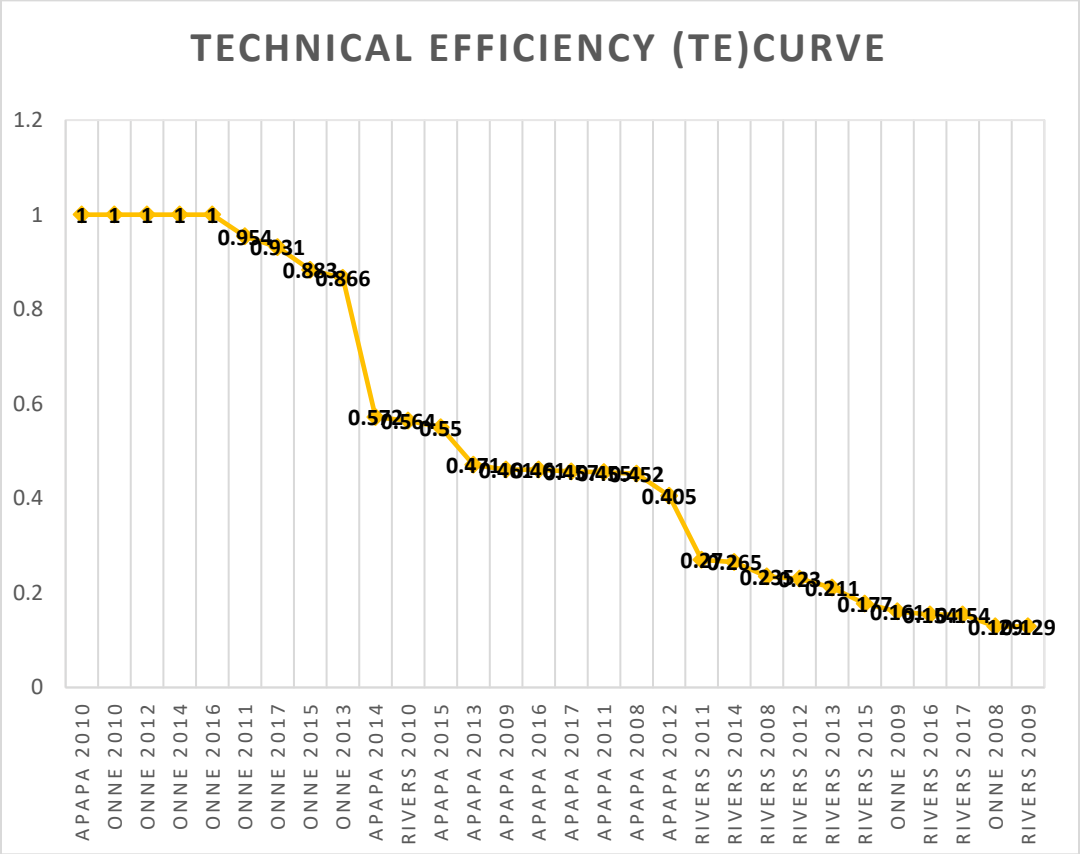

Figure 4.1: Technical Efficiency Curve of the DMUs, using DEAP CRS-Model.

From Table 4.2, Rivers port has never been efficient. The port is the most inefficient among the seaports considered. Apart from the global economic downturn in trade across the globe, which affected its performance in the early years of 2008 and 2009, Rivers port is not very accessible.

5. CONCLUSION

It is clear that Nigerian ports are not efficient. However, Onne port performed better in the comparative analysis. Apapa is also inefficient in most of the year studied and Rivers port perform generally inefficiently over the periods of the study. The competitiveness among the ports also affects their relative performance. Rivers port should be privatized to improve its efficiency level and Onne port should be used to benchmark other Nigerian ports.

Recommendation

It is recommended that:

1. Rivers port should be privatized to improve its efficiency level, because of its poor operational performance compared to Apapa and Onne ports.
2. Onne port which outperformed Apapa and Rivers ports should be used to benchmark other Nigerian ports.
3. The government should improve accessibility in and around the port by providing better road and rail network for better performance of the ports.
4. Efficiency and human capacity of the port should also be improved by training.

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Conflicts of interests

The authors declare that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

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